

Internship at the Office of the Chief Scientist

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Abstract

The NASA Ames Research Center (ARC) Office of the Chief Scientist (OCS) is part of the Center Management, the OCS adds value to the organization by encouraging and facilitating innovation and value to the Agency, Nation, and the scientific community through its well-developed, diverse, and strategically formed charter. The OCS provides the Center with the oversight and advice by facilitating and evaluating the Scientific Innovation Fund (SIF) and promoting science-based research partnerships. Additionally, the Office contributes to the Agency by organizing annual Summer Series Colloquia, Workshops, and support to the Early Career Network, which allows for international and inter-agency collaborations. Working at the OCS allowed me to further learn about the working of the Office and how the Office engages and provides guidance with rest of the Center and the Agency. As part of my internship, I am working on developing the initial infrastructure required for the organization of the Standardized Distributed Workshop and further developing the layout for the Hibernation Workshop. The Standardized Distributed System workshop will investigate the scope of developing and using standardized distributed systems for a wide range of applications including satellite systems, aerospace-oriented systems, water-based systems, automobiles, and various other robotics applications. The goal of this workshop is to determine the feasibility of developing a standardized distributed system that can be customized for different technological applications, which will enable resource sharing, openness, robustness, and fault tolerance. This workshop will bring together experts from different fields, including satellite operations, unmanned aerial vehicles, aircraft operation and management, and artificial intelligence to provide a global evaluation of the aspects associated with the development and adoption of distributed systems. The workshop will also, guide the participants through state of the art distributed systems, discuss some of the challenges in designing control systems with a distributed structure, and consider the future of distributed system based technologies for future applications. Additionally, I am also working on finalizing the details and documentation for the proposed Hibernation Workshop. This workshop will address the phenomenon of hibernation through three major aspects: hibernation on Earth, hibernation in space, and knowledge gaps in the approaches to future deep space exploration. The primary objective of the workshop is to explore the current state of science in the area of hibernation, and as a scientific community, explore the gaps and challenges preventing this scientific field from advancing to the next level. This workshop will consist of presentations, panel discussions, and breakout sessions focused on addressing this scientific field, and bringing experts from educational and commercial sectors together. This report documents the process of planning these workshops, further provide a brief summary of my experience with the 2016 NASA Ames Summer Series and various professional visits.

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List of Acronyms

NASA – National Aeronautics and Space Administration

OCS – Office of the Chief Scientist

ARC – Ames Research Center

SIF – Scientific Innovation Fund

SDS – Standardized Distributed Systems

AI – Artificial Intelligence

LEO – Low Earth Orbit

ISS – International Space Station

ISRU – In-situ resource utilization

US – United States

UN – United Nations

ROS – Robot Operating System

WWW – World Wide Web

AUTOSAR – AUTomotive Open System ARchitecture

NRP – NASA Research Park

Introduction

Internship at the Office of the Chief Scientist allowed me to interact with various different elements of the office. The primary focus of the internship was to define the framework for the Standardized Distributed Systems (SDS) workshop to be conducted in the Fall of this year. The main objective of this workshop is to bring together experts from various industries to determine the feasibility of creating an integrated distributed system which may be utilized for a variety of robotic and computational applications. In addition to the distributed systems, I had to further work on the previously developed hibernation workshop.

This report is divided into three important chapters, Chapter 1 introduces the principles of distributed systems, its advantages over other computing architectures, followed by the summary of the developments made in different fields. The chapter following that introduces the importance of hibernation research in order to enable long-duration spaceflight. Following Chapter 3-5 summarizes the 2016 Summer Series, the outline of the workshops, and summary of the professional visits conducted during the internship. The report is concluded with the Recommendations and Conclusions section, which provides an overview of the future work required to be done.

Chapter 1: Distributed Systems

The SDS workshop will help explore and determine the feasibility of developing a standardized platform, which allows communication, interaction, and control between various different applications. Furthermore, this workshop will include experts from varying fields, to gauge a global perspective on SDS. This development of this platform is intended to provide an interface which eases the degree of complexity required to develop a particular application, hence increasing the degree of resource sharing, openness, and standardization in the system development. The following section will introduce the various types of systems architectures currently utilized as a control system, followed by the advantages of adopting a standardized system based on a distributed architecture, and the adoption of distributed system in different fields, and finally, this section will conclude with the scope and objectives of the workshop.

The system architecture is the conceptual model which helps determine the behavior, structure, and nature of a system (System architecture, 2016). There are various types of system architectures that have been established for computing and control systems. In the past, there have been typically three types of architectures that have been used for various control systems, including centralized, distributed, and federated. Central system architecture utilizes a single centralized hardware and software frameworks which are then used for several other subsystems. (Šegvić, Krajček, and Ivanjko, 2015). This type of architecture primarily uses one central location for all the hardware and software controls and system calculations. Distributed architecture on the other uses a more distributed framework for hardware and software requirements of the system. Contrary to centralized architecture, the data and analyses are transmitted between various subsystem allowing inter-subsystem interaction and communication. Federated system architecture provides a combination of both central and distributed architecture types, which utilized distributed framework for hardware requirements and a centralized framework for software requirements, allowing more number of subsystems in comparison to central architectures, and less number of subsystems in comparison to distributed architecture (Šegvić, Krajček, and Ivanjko, 2015). Increase in the use of decentralization and affordable computing resources lead to the adoption of following four types of system computational architectures:

- I. Integrated – Similar to the central system the computational capabilities are stored in one location, and this architecture type is only used for one single purpose and/or workload. The system development and advancement results through the entire system replacement (Bilderbeek and », 2013).
- II. Distributed – This architecture is developed to enable growth and encourage system expansion, by allowing a collection of an independent system to work coherently and appear as a single system to the end user. This system architecture eliminates the need

- for entire system replacement for enabling system developments and upgrades (Bilderbeek and », 2013).
- III. Pooled – Utilizes resource pools consisting of computational, storage, and data blocks. System development takes place by replacing and/or adding blocks in a different resource pool. This architecture enables efficient scaling and growth of the system (Bilderbeek and », 2013).
- IV. Converged – This architecture offers a combination of pooled and distributed system frameworks. This includes a set of individual resource pools jointly connected in a single chassis. System upgrade can take place by replacing the single component in the chassis and/or by adding components to the chassis. This design is effective in developing a rapid deployment of multiple payloads.

Advantages of Distributed Systems

A distributed system can be much larger and more powerful given the combined capabilities of the distributed components, than solely the combinations of stand-alone systems. A distributed system is only determined to be useful due to its ability to add reliability to the system, which is a difficult goal to achieve because of the complexity of the interactions between simultaneously running components. Distributed systems are relatively easy to expand due to its independent subsystem composition, hence providing a flexible communication for various different applications (Tanenebaum and Steen, 2016). One of the most challenging aspects of using distributed systems is their ability to operate during the component failure. A distributed system demonstrates resources accessible, openness, scalability, and coherent functioning. In order for a standardized distributed system to work effectively and allow data exchange between different subsystems and applications, the following capabilities must be incorporated into a standardized distributed platform.

- Resource Accessibility – This feature allows easy access and efficient control of remote resources, which enables the ability to use hardware and software anywhere in the system (Emmerich, 1997). This allows connecting users and resources which further results in easier interaction and exchange of information.
- Transparency – An essential feature of the distributed system is to “hide the fact that its processes and resources are physically distributed across multiple systems (Tanenebaum and Steen, 2016).” Transparency of the system allows easy and smooth interaction and communication with the end user preventing any obstruction from the presence of any of the different components present in the system.
- Concurrency – allows concurrent execution of the components access and share in the distributed systems, which helps improve the integrity of the system (Tanenebaum and Steen, 2016).

- Openness – determines the ability of the system to extend its capabilities to different subsystems and applications. This feature is primarily associated with the interface requirements and integration of the components of the system.
- Scalability – ability to operate when some aspects of the system are scaled to a larger size. The scalability feature of a distributed systems enables an increase in the frequency of network outages preventing degradation of the scalable system. and could degrade a "non-scalable" system. Similarly, we might increase the number of users or servers or overall load on the system. In a scalable system, this should not have a significant effect.
- Security – enabling system authentication to protect data and services over the distributed system network.
- Fault Tolerance – System's ability to recover from component failure without performing intermediate correction steps.
- Transparency – System's ability to provide desired responsiveness in a timely manner.
- Recoverability – System's ability for the components to restart after recovery of a system from failure.
- Consistency – The system can coordinate actions by multiple components often in the presence of concurrency and failure. This underlies the ability of a distributed system to act like a non-distributed system.

Distributed Systems provide various advantages over the other types of architectures, however, the open resourcefulness and connectivity of this platform make the system more susceptible to security breaches or intrusions in the communications (Tanenebaum and Steen, 2016). Security of the overall system is becoming increasingly important due to the connectivity and resource sharing of the different components of the system. Proper security measures are required to be placed in the system in order to ensure the integrity of the data and information transferred across the system.

Application Specific Distributed Systems

Distributed systems are not only limited to IT or computer sciences, there is a trend of developing distributed system architecture in different fields such as aerospace, autonomous vehicles, robotics, satellite operations, etc. One of the most well known distributed interface used by millions of people across the globe is the World Wide Web (www). This example demonstrates the advantages of using a standard web browser that allows users access to information stored on web browser located anywhere on the globe. WWW is an example of an efficient distributed system that appears to the end users as a single resource (Distributed Generation: Definitions, Benefits, Technologies & Challenges, 2016). Similar in nature to the WWW platform, various other industries have explored the potential of using distributed architecture for various applications. This section summarizes the development and growth of using distributed computing platforms in different fields including robotics, autonomous vehicles, spacecraft, etc.

Robotics

In the present day, technology, specifically, robotic applications are integrated into the system different in various forms ranging from industrial applications, health industry, education, e-commerce, automation, and artificial intelligence. Additionally, robotics and autonomous systems are continuing to change the way space exploration is conducted, which in turn influences the humans and the nature of the future human missions in the Solar System. The present technology used for various robotic applications is involved uses multi-robotic systems. And, there are currently various challenges associated with identifying the essential advantages of using multi-robotic systems, human ability to control and the multi-robotic applications, ability of a robotic system to conduct passive action recognition, and the complexity and affect of the environment and task on the design of multi-robotic systems (Parker, n.d.).

Distributed robotic systems have been used in practice since the late 1980s, and adoption of distribution architecture has resulted to an increase in the use of multi-robotic systems (Parker, n.d.). Prior to the 1980s, research has mostly been limited to the use of single robotic systems or distributed problem-solving systems, these two applications did not involve using distributed systems for robotic application. However, since then there has been significant progress and development made in this field, and use of distributed robotic applications have addressed a much wider variety of topics (Parker, n.d.).

One of the examples of the distributed systems that have been established for a vast range of robotic application is the Robot Operating System (ROS), which is flexible the framework used to program and developing software for various types of robotic applications. It provides a standardized platform that can be used for general robotic control, abstraction, implementation of common functionalities, and other data package installation and management (Patel, 2016). From the point of view of robotic programming, it is significantly difficult to create a general purpose software because of the complexity of varying task and environments. The ability to deal with such ambiguity makes the problem even more complex, therefore ROS provides an open source platform that allows continuous development of a various library of the software and allows further advancement of mapping, navigation, computer vision, etc. characteristics.

The following will summarize the current state of the art specifically in the field of cooperative multiple mobile robotics, and provide an overview of the developments and the lack of maturity still prevalent in this sector. The following summarizes the current state of the art in distributed robotic systems and the current issues associated with the use of distributed multi-robotic systems. The following are the eight identified areas that vastly implement and influences the use of multi-robotic distributed systems,

- Biological Inspirations

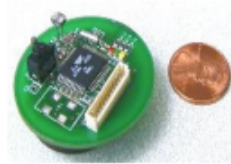
Development of distributed and cooperative mobile robotic technology is primarily based on the robotic paradigm of behavior-based control, which has been rooted to biological inspirations (Parker, n.d.). Social behaviors observed in nature through the insects, animals, and plants have been determined to be beneficial to the design of robotic systems. Control rules witnesses in various biological societies of ants, bees, and birds are instructive to the development of similar nature of cooperative robotics systems. This can be demonstrated by the ability of multiple robotic systems to “flock, disperse, aggregate, forage, and follow trails (Parker, n.d.).” Development of various multi-robotic systems have resulted from the cooperation witnessed in the dynamics of ecosystems, predator-prey systems, and cooperation among higher animals, such as wolf packs (Nagpal, n.d.). There are several processes and trends witnessed in nature and their applicability to the development of the robotic system has been well understood. However, there is still more development and advancement required to be made in this domain, for example, there are still various biological trends that have been identified by the ability to apply them to the robotic application is still unknown (Nagpal, n.d.). This primarily includes the use of imitation witnessed in higher animal class, and extend it to robots resulting in learning new tasks and behaviors, and using

interconnectivity demonstrated by insects to enable navigation over the challenging and unpredictable terrain.

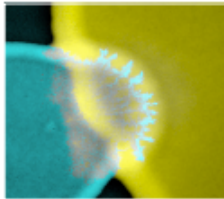
Distributed Systems



Swarm robotics



Sensor Networks



Synthetic Biology



Reconfigurable Robots

Inspiration: Biological Systems

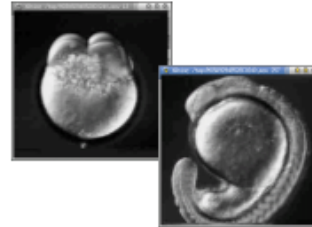


Figure 1

- Communications

Communication between different robotic systems in a distributed system is complicated in nature and has been studied since the inception of this research. Communications can be divided into two categories, implicit, resultant of side-effects of various actions, and explicit communication, which is programmed to allow different sub-systems to communicate amongst the system. The inclusion of communication ability in a robotic distributed system adds value to the application and has been proven to achieve fault-tolerance in multi-robotics systems. The fault tolerance mechanism has been identified in terms of setting up and maintaining distributed communication networks and ensuring high reliability in inter-system communication (Parker, n.d.). A significant improvement is still required to be made in order to enable reliable communication in faulty and unpredictable environments. However, the potential to use a single general architecture that can be extended to a much wider verity of domains is still not be evaluated or considered. The feasibility of using a specialized architecture

- Machine Learning

Multi-robot system learning, specifically focusing on cooperative task learning are one of the areas in which significant research is required to be invested. Specifically challenging for a distributed robotic system is to introduce learning that is intrinsically cooperative, i.e. where the action of sub-system directly influence the action and/or task performed by another robotic sub-system. The primary reason for the complexity of conducting this task is the inability to break down inherently cooperative tasks into independent sub-tasks, hence it is required for the entire system to execute the action through a combined action of the entire system rather than the action of individual sub-systems.

- Planning and Control

Development and advancement of distributed robotic systems have primarily been driven by architectures, task planning capability, and control allocation. Distributed architectures for robotic systems, so far, have only be used to help introduce one specific type of capability to the system, and this capability is generally seen in the context of task planning, fault tolerance, etc. In order to design a homogenous distributed robotic system, it is essential to identify and address issues related to action selection, control, delegation authority, the coherence of actions, and conflict resolution.

- **Motion and Reconfiguration**

One of the important characteristics of a robotic system is its ability to move and reconfigure through a terrain, and further, predict potential path and motion sequence in an unknown environment. Path planning, motion control, motion coordination, traffic control, formation generation, and formation keeping (Parker, n.d.), are few of the important identified characteristics required to be demonstrated by a multi-robotic system. Use of distributed architectures for robotic systems have resulted in research in this field, but most of the works aimed only in the 2D domain which limits the ability to exist path planning work. Additionally, reconfiguration ability of the robotic system allows them to achieve desired functions through different subsystem shapes, by allowing the robotic subsystem to connect and reconnect to form varying shapes to serve the desired function. This feature of the multi-robotic system increases the

Autonomous Vehicles

Autonomous Cars

Autonomous vehicles are capable of reacting to their external environment by perceiving the situation through the sensors, actuator, computers, mapping, and planning control installed within them without requiring any human intervention. Development of an autonomous car requires integration from two separate industries, automotive and mobile robot industry. The automobile industry provides the robust and reliable mechanical and electrical structure required by the vehicle and the robotics industry provides the driving algorithm required to make the vehicle autonomous. Since, the car industry has a very specific set of requirements based on its environment, and this primarily drives development of the intelligence required for an autonomous car, and the development of this intelligence system is based on a standardized platform that allows communication and cooperation between the hardware and software (Jo et al., 2014). This globally accepted standardized software architecture is called the AUTomotive Open System ARchitecture (AUTOSAR), this architecture provides guidance for developing the automotive software and additionally provides basis design models and methodology.

Five important aspects of an autonomous vehicle include localization, vehicle control, planning, systems management, and perception. These features of a self-driving care are represented in the following figure.

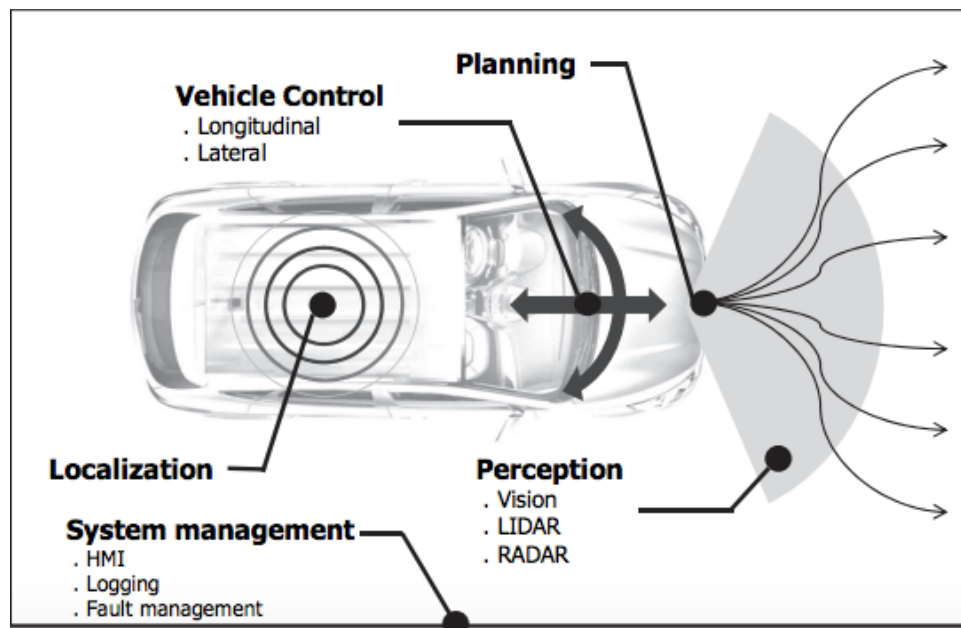


Figure 2: Basic features of autonomous cars (Jo et al., 2014).

In addition to the five basic functions mentioned above there are various different functional sub-components depending on the complexity of the vehicle. The function of the sub-components is presented in the following image.

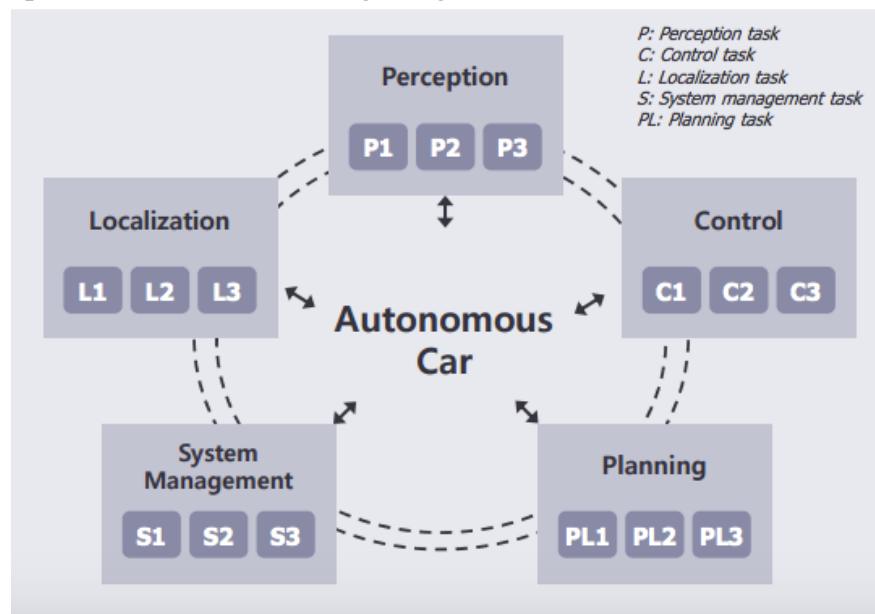


Figure 3: Functional sub-components (Jo et al., 2014).

Self-driving cars utilize complex, autonomous, and homogenous algorithms to conduct complex driving algorithms, and the functioning of the algorithms is based on the nature of the implementation of subcomponents of each function. The following section summarizes the

design requirements, development, and benefits of using distributed system architecture for autonomous vehicles by comparing it to the centralized system architecture.

- **Centralized Architecture**

In a centralized framework, the functional components of an autonomous vehicle are controlled by a single computing unit. The sensors and actuators of the vehicle are connected to a centralized single control unit. The centralized system utilized simplified system configuration. However, due to the use of a single control unit, the centralized system requires high computation capabilities due to the complexity of the autonomous algorithms, furthermore centralized system may also lack scalability, fault tolerance, and ability to handle software malfunction (Jo et al., 2014). Finally, centralized structures are very difficult for development and testing purposes due to the lack of subsystem concurrency. The centralized structure used by an autonomous vehicle system is further described through the following diagram.

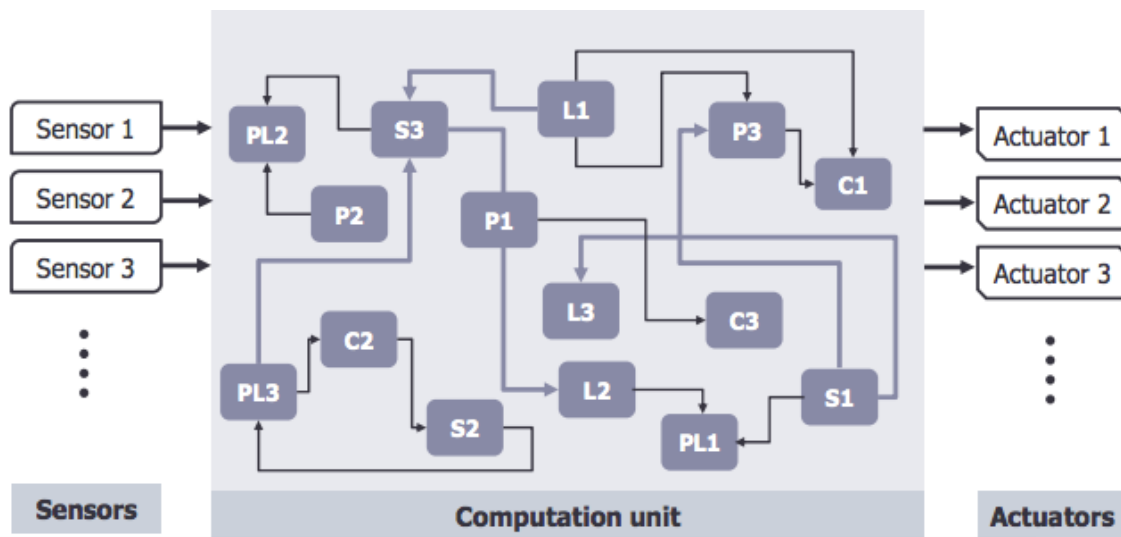


Figure 4

- **Distributed Architecture for Autonomous Cars**

In a distributed architecture, there are independent control units implemented for each functional sub-component of the autonomous vehicle. Use of a distributed architecture results in lower computational complexity of the system, the overall autonomous system algorithm can be scaled depending on the mission objectives and requirements. Further more, use of distributed system results in an increase in the computation capability of each subsystem, and the overall performance of the system is increases due to the parallel computation of independent subcomponent

functions. In comparison to the centralized system each module of this system can independently be developed, tested, monitored, and maintained, and does not require replacement of the entire system. The following diagram illustrates the distributed system of an autonomous vehicle, which results in higher system reliability.

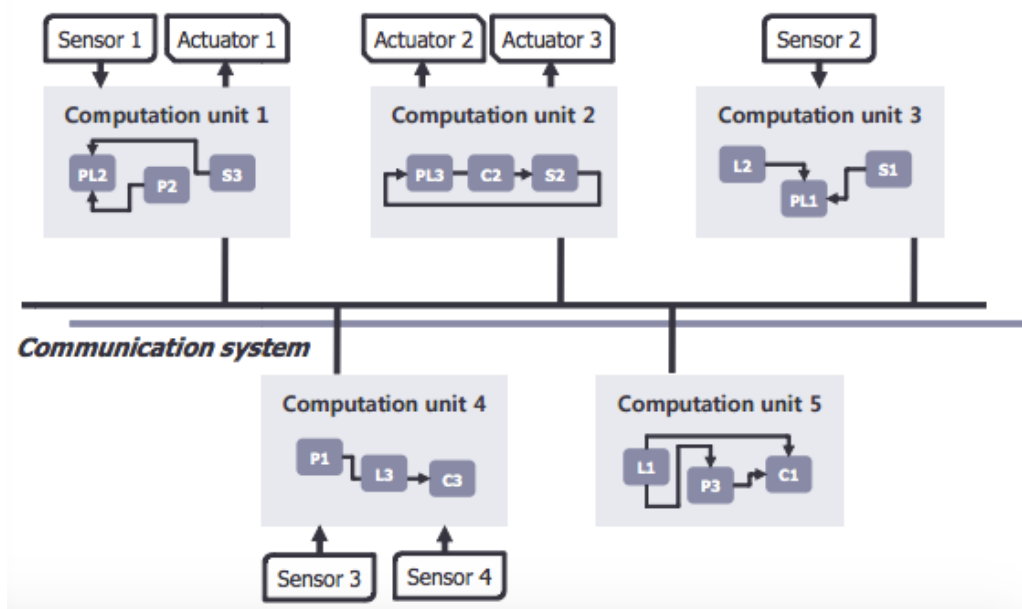


Figure 5

Satellite Operations

Distributed computing architectures offer numerous advantages in developing complex devices and control systems, some of the advantages include “well-defined interfaces, flexible composition, streamlined integration, straightforward function-structure mappings, standardized components, incremental testing, and other benefits (Palmintier et. al., 2001).” In the context of distributed spacecraft architecture framework allows distributed control between the various spacecraft subsystems, between different satellites in a multi-satellite system, and between the spacecraft and the ground segments (Palmintier et. al., 2001). In the past most of the satellite constellations used for weather monitoring, navigation, and data replay have utilized monolithic architectures, and the increase in the use of distributed satellite constellations have significantly decreased the size and mass of the spacecraft without compromising its operational capabilities, the following are the benefits of using distributed satellite structures over their monolithic counterparts:

1. Decrease in launch mass and launch cost

The primary source of the cost associated with a satellite is primarily dependent on the cost of the satellite acquisition and launch. Use of distributed constellation structure would decrease the mass and size of the satellite by requiring less payload mass and supporting structure in comparison to monolithic satellite structures. Small satellites do not require a designated launch, hence resulting in significantly lower launch cost, and the number of satellites launched per launch can significantly increase due to the decrease in size and mass of per satellite unit.

2. Increased Performance

Small satellites can be launched faster and cheaper, hence resulting in faster service and more orbit coverage in a short amount of time. On the other hand, a constellation with non-distributed architectures require large-scale satellite models in order to compensate for the lack of distributed computing between different units within a constellation, and therefore resulting in significantly more time to provide similar service coverage.

3. Fault and failure resistant

Satellites in space are subjected to extreme environments and conditions resulting degradation over time, when monolithic satellites are subjected to failure they result in loss of entire system capacity. However, unit failure in small satellites constellation with distributed computing does not disrupt the service, and additional satellites from the ground can be launched into orbit much more quickly and at a comparatively less cost. Moreover, the size of these multi-satellite distributed structures is prone to damage due to orbital debris due to its miniaturization.

Chapter 2: Hibernation for Humans Spaceflight

The human body is not built to withstand the harsh environment of the deep space. Human body requires an optimal range of temperature and a steady supply of food, water, and breathable air for survival. The issues and challenges associated with providing a continuous supply of resources for deep space missions are not feasible due to limited mass per launch. Therefore, in order to ensure that humans can leave the envelope of the solar system and experience interstellar space, it is required to develop mechanisms that allow humans to adapt to the changing environment of space or intentionally placing the human body in an inactive state and altering the temperature of the human body that allows preservation of their bodies and not require frequent intake of nutrients. Long-term cryogenic or hibernative sleep may be the key that enables long distance human mission beyond the orbit of Mars (Bulger, 2015). Crew hibernation for long duration spaceflight helps in the reduction in mission consumables, reduction in pressurized volume requirements, minimized various ancillary crew accommodation, and also, minimizes the psychological challenges of a spaceflight (Bradford and Talk, 2014). The amount of mass saved in resources and accommodation can be utilized to increase mass margin, increase radiation shielding, expand launch opportunities, and decrease launch cost.

Current and near-term focus on space exploration is revolving around the use of unmanned missions. In order to ensure the human presence in space and on outer planets, it is essential to identify enabling technologies for human missions. In order for humans to travel long distances, it is important to minimize the transition time, which is only possible due to the advancements in the field of rocket propulsion. Once, in transit, humans require an optimal balance of gravity, oxygen, food, and water to ensure survival, and this is only possible through the development of efficient, closed-loop support systems. Apart from the limitations of the current propulsion systems, and the slow development of closed-loop support systems, processes observed in nature, such as animal hibernation to ensure long-term survival have inspired the concept of human hibernation to withstand and survive extreme environments of space. Hibernation is one of the few types of dormancy displayed by animals. The five states witnessed in nature include sleep, torpor, hibernation, winter sleep, and aestivation (aka. summer sleep) (Ayre, Zancanaro, & Malatesta, 2004). Applying the concept of hibernation to humans only patterns and trends observed in Mammalia hibernation is considered to their phenotypical and genotypical similarity with humans. In order to place a human body into hibernation, the following set of observation is made in the given order,

1. Pre-bout Strategies, bout is referred to as the action taken to enter and exit state of hibernation)
2. Early bout and bout strategies
3. Gene expression change

4. Post bout strategies s

Various different types of hibernations are witnessed in nature, and the nature of the types of this hibernation is summarized as follow:

- Obligate Hibernators

In this state of hibernation, the body spontaneously enters hibernation regardless of the ambient temperature or access to nutrients or water. This type of hibernation is characterized by periodic arousals of where the temperature and heart rate of the body reaches normal levels.

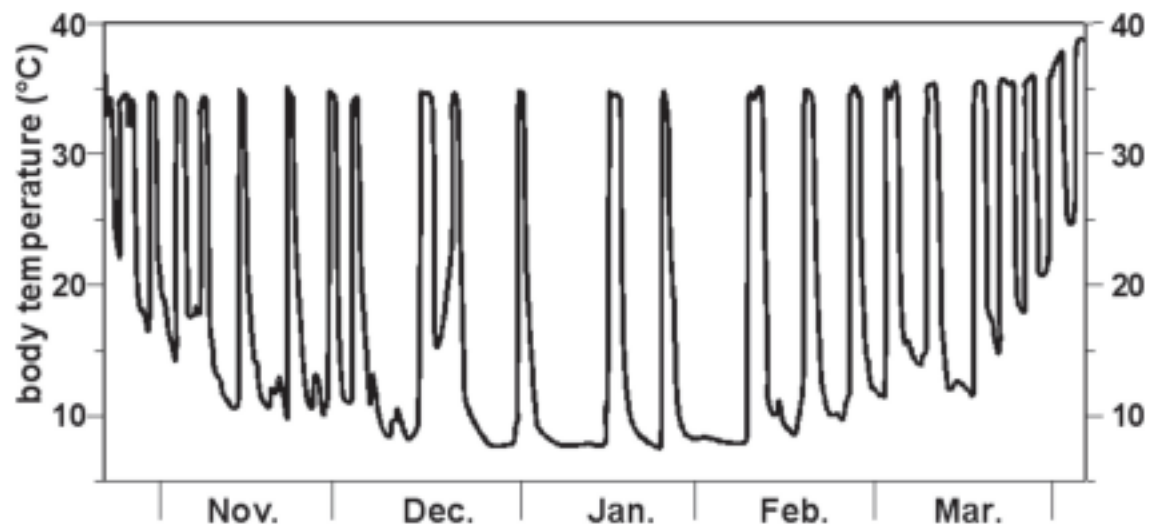


Figure 6: Periodic arousals in body temperature (Ayre, Zancanaro, & Malatesta, 2004)

- Facultative Hibernators

Mammals under this scenario only enter hibernation under an extreme scenario of stress, food deprivation, and to ensure survival. Some of the sources of stress for astronauts on a space mission are demonstrated in the following diagram.

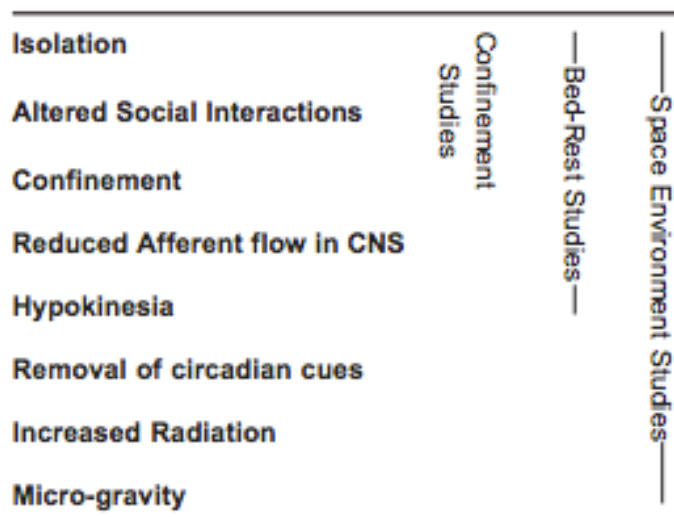


Figure 7: Stress factors (Ayre, Zancanaro, & Malatesta, 2004)

- Torpor

Under this scenario, metabolism is suppressed to minimize the decrease in overall body temperature and to ensure energy saving for the period with low ambient temperatures.

Hibernation has been witnessed in different species of animals. The patterns of hibernation and the duration of hibernation experienced in different types of species of animals is listed in Table 1.

Table 1: Hibernation in terrestrial animals (Bradford and Talk, 2014)

Species	Hibernation Duration [months]	Notes
Black Bears	3 – 5	This require reduction in at least n 25 to 30 % of body mass.
Artctic Ground Squirrels	Up to 6	Experience different body temperature reduction. temperature of the body
Marmot	4.5 – 8.5	
Prarie dog	4 – 5	Can awake spontaneously to gather resources (such as food and water)
Ground hog	Upto tp 6.;	Body temperature changes and the heart rate slows down

		to approximately 4 beats per minute.
Dwarf Lemur	4 – 6	These are the only primates that are known to hibernate and result in the metabolic rate reduction to 2% of active rate.

There are three potential ways of inducing coma into humans, and have been identified as follows:

1. Temperature Based Hibernation

This is achieved by lowering the temperature of the human through invasive cooling, or conductive cooling, through the use of external gel pads.

2. Chemical and/or drug Based Hibernation

Hibernation can be easily induced by activating adenosine receptor and an experiment conducted by the University of Alaska demonstrate that inhaling hydrogen sulfide resulted in deep hibernation state of mice resulting in the reduction of oxygen demand per cell (Bradford and Talk, 2014).

3. Brain Synaptic-based Hibernation

This is supported by the research focused on the decrease in the “number of dendritic spines along the whole passed of apical dendrites in hibernating mammals (Bradford and Talk, 2014).”

Chapter 3: Summer Series

The OCS organizes annual colloquium at NASA Ames, bringing together experts from various different fields. These talks provide a platform that creates room for innovative discussion and “inspiration to catalyze scientific progress, share ideas, and communicate new and exciting concepts.” This year the summer series comprise of over 17 talks over a span of three months from June 7th, 2016 to August 19th, 2016. This year’s summer series featured topics ranging from quantum mechanics, the physics of aero structures, reinvention of planetary exploration, and searching in harsh environment, etc. As a part of the office I assist in the execution of these seminar, which allows me to learn about the team building skills required to successfully conduct the colloquium, and further gain knowledge in different fields from the experts. The following is the list of the speakers that presented at this year’s summer series and the overview of their talks.

Jin-Hoon Han – Vacuum Electronics in a Nanometer Era

The increasing complexity of robotic space exploration requires the use of advanced and critical avionics. However, the quest to explore the unknown can be hindered by the degradation of the spacecraft components and equipment due to the presence of radiation and cosmic rays. Dr. Han talked primarily focused on the implications and severity of radiation on space electronics for missions beyond the LEO.

Mark Kasevich – Quantum Mechanics at Macroscopic Scales

Quantum mechanics is critically important in understanding the foundation of molecular composition and distribution in physics, chemistry, and material sciences. Mark Kasevich, professor of physics and applied physics at Stanford University talked about utilizing the characteristics of atom interferometry to improve navigation.

Vytas SunSpiral – SUPERball: A Biologically Inspired Robot for Planetary Exploration

Biology and nature have inspired the design and development of various systems in the field of robotics and engineering. Dr. SunSpiral talked about his work on Tensegrity robot for planetary missions. This robotic application is essentially inspired by the sense of adaptability witnessed in the structure and movement of muscles and bones.

Kenneth Cheung – Building Blocks for Aerostructures

Advancement in the design of future aircraft is driven by the development of light-weight, high-reliability composite structures, which increases maneuverability, efficiency, and performance of vehicles. Dr. Cheung talked about his work in this field of cellular composite building blocks and digital materials in order to create transformable aerostructures.

Charles Bolden – Exploration and the Journey to Mars

Charlie Bolden is the 12th NASA Administrator, prior to his role as the administrator he served the US military and piloted STS-61-C and STS-31 shuttle missions. During his talk, he discussed NASA's current exploration roadmap, titled, Journey to Mars, and the planned course of action for NASA to achieve the set objectives and goals.

Thomas Barclay – Microlensing and the K2 Experiment

Kepler mission was designed to discover planets like Earth orbiting around other stars in the galaxy. This mission helped identify various exoplanets, such as the gas-giants, hot super-Earths, and ice giants, which has significantly increased our understanding of the different types of exoplanets. Failure of the reaction wheels of the Kepler satellite in 2013 led to the formation of K2 experiment. Dr. Barclay discussed in detail about the emergence of the K2 mission and introduction of the micro-lensing experiment.

Tery Fong – Planetary Exploration Reinvented

Humanity has been intrigued for centuries about the existence of life on other planets. Humanity's curiosity to explore the unknown is pushing our technological boundaries to conduct exploration missions to further learn more about the universe. Past exploration mission have primarily been restricted to robotic spacecrafts, landers, and surface landers. In his talk, Dr. Fong talked about the potential ways to develop new techniques that will enhance our ability to explore space.

Ophir Frieder – Searching Harsh Environments

Searching and recovering scanned hardcopy formats of documents may often compromise the quality of text, images, signatures, graphics, etc. Therefore, NASA's Mission Assurance System aims to provide a robust and efficient platform that allows out ability to capture and search data, and increases our ability to process complex documents. Dr. Ophir introduced the nature of the complexity of processing digital data while maintaining the quality of text, data, and graphics.

Elizabeth Nyamayaro – How to Create a Social Movement

Elizabeth Nyamayaro is the senior advisor to the executive director of UN women director and she spearheaded HeForShe movement, which has resulted in an impact on over 2 billion people. During her talk, she talked about the factors that drove HeForShe movement and the importance of promoting gender equality in today's world.

Norman Mineta

Mr. Norman Mineta is the 33rd United States Secretary of Commerce and served as the United States Secretary of Transportation under the presidency of President George W. Bush. Mr. Mineta's talk catered to a large number of audience, he shared a vast range of things including struggles of his family as immigrated in the US, childhood experience, and his experience in the US Army and the military.

Barbara Block – Sushi and Satellites: Tracking Predators Across the Blue Serengeti

Dr. Barbara talked about her research focused on how large pelagic fish utilize the open waters, and her work in successfully implanting tags on tuna, in order to track their movement patterns, behavior, and population structures. This study has been significantly important in furthering our understanding of the marine ecosystem.

Eugene Tu – Dynamics and Flow: From Ames Intern to Center Director

Eugene Tu is the newly appointed center director at NASA Ames Research Center. During his talk, he talked his career trajectory has certainly been very interesting, starting out as a young professional in the field of Aerospace Engineering, and making his way up to the position of the center director. Additionally, he provided advice for various engineering student and/or young professionals, who are either starting school or beginning their career in the field of aerospace.

Michael Flynn – Synthetic Biological Membrane

In order to ensure human presence on a planet other than Earth, it is important to develop continuous life-support systems that can help sustain human presence outside the comfortable environment and domain of this planet. Therefore, in order to make this happen it is required to develop technology and mechanisms that can perform the task of creating an external environment that ensures human survival. Dr. Flynn talked about his proposal for the water recycling unit on the ISS, and further discussed his work on developing a water filtration unit to be used in the space habitats and stations.

Jason Dunn – The Future of Making Things in Space

Creating manufacturing possible in space tremendously decreases the cost associated with the launch. Therefore, in order to ensure efficient and space development and space resource utilization, it is important to develop ways to manufacture in space and adapt ISRU. Jason Dunn talked about the progress and the achievements made by his company, Made In Space, proving 3D printing technology in microgravity on the ISS, and their role in the future space exploration.

Penelope Boston – Subsurface Astrobiology: Cave Habitats on Earth, Mars, and Beyond

Finding life on another planet in the solar system is one of the longest endeavors of mankind. In order for the humanity to devise strategic ways to explore potential life-supporting worlds, it is essential for us to understand the existence of life in extreme conditions. Dr. Penelope Boston, the new director of NASA Ames's Astrobiology Institute talked about the importance of understanding the origin and formation in some of the most diverse caves here on Earth, and using this knowledge to further our search for life in the universe.

Alan Stern – The Exploration of Pluto by New Horizons

Interplanetary exploration is an essential endeavor for humanity to undertake in order ensure the continuation of our civilization. Robotic exploration of planetary bodies, asteroids, and comets in our Solar System is of great importance to the scientific community, as it allows us to fill current gaps in our knowledge and further allow technological development and advancement. Dr. Alan Stern talked about New Horizon, the first mission to Pluto, the scientific knowledge gained through this mission regarding the icy worlds at the edge of the Solar System, and the potential extension of the mission to explore the Kuiper belt objects.

Bethany Ehlmann – Early Mars: A View from Rovers and Orbiters

Astrobiology identifies water as an important bio-signature when searching for life. Surface and orbital interplanetary missions have allowed us to gain knowledge and information about the environmental, surface, and habitability conditions of various planets in our Solar System. Dr. Ehlmann talked about the importance of remote compositional analysis of planetary surfaces and her research focused on infrared spectroscopy, habitability, and geochemistry of water.

Chapter 4: Development of the Workshops

Standardized Distributed Systems (SDS)

Scope

Distributed systems are a set of multiple independent system which are appear to the end users as one coherent system. They provide a powerful computation platform that combines capabilities of the distributed components rather than just providing combinations of stand-alone systems. A distributed system is determined to useful due to its ability to add reliability to the system. The process of deploying and developing large-scale distributed system for wide range of applications is challenging in nature due to the criticality of the intersecting pathways between computer science, computational science, and various scientific applications. Over the years, the development of a standardization of the distributed systems have been lagged behind other developments in cyber-infrastructure.

Objectives

The primary objective of the workshop is to investigate the scope of developing and determining the technological and economic feasibility of developing a standardized distributed system for a wide range of applications including aerospace systems, water-based systems, computer science, artificial intelligence, autonomous vehicles, information technology sector and various other robotics applications. Another objective of this workshop is to determine a technological framework required to develop standardized distributed system that can be customized for different technological applications, which will enable resource sharing, openness, robustness, and fault tolerance. This workshop will bring together experts from different fields, including satellite operations, unmanned aerial vehicles, aircraft operation and management, artificial intelligence, and biology to provide a global perspective of the aspects associated with the development and adoption of distributed systems. The workshop will also, guide the participants through state of the art distributed systems, discuss some of the challenges in designing control systems with a distributed structure, and consider the future of distributed system based technologies for varying applications.

Workshop Outcomes

This workshop is designed to provide an immersive learning experience to all the participants, the layout of the workshop will allow participants to engage and network with diverse range of experts and professionals from academia and the industry. The workshop will allow open access to presenters' abstracts, presentations, and reports resultant of the workshop. The workshop will also provide future publication and collaboration opportunities.

Hibernation Workshop

Hibernation, coma, and depressed metabolism are some of the very interesting and intriguing approaches considered to enable long duration human spaceflights. Hibernation results in various ethical and legal aspects that are required to be addressed along with the technological advancement required to enable human hibernation and depressed metabolism. The workshop aims to address the phenomenon of hibernation by exploring the concept of hibernation on Earth, hibernation in space, and the knowledge and technological gaps in the approaches to enable hibernation. The primary objectives of the workshop include:

- Understanding the current research in the area of hibernation
- Allowing the scientific community to explore the gaps and challenges preventing the current scientific community from advancing to the next level
- Creating networking opportunities and potential collaborations with experts in industry, academia and various government agencies.
- Publication in a journal.

The workshop comprises of presentation, panel discussions, and breakout sessions and the workshop will be conducted in the following three major sections.

- Hibernation on Earth
Hibernation observed in different species of animals on Earth will be discussed here, followed by studying the hibernation patterns observed in bears, as the hibernation period experienced by them is the longest in comparison to other terrestrial animals. In this segment, existing research relevant to cryogenic sleep in humans for medical purposes will also be analyzed and the various types of mechanisms of inducing coma will be discussed.
- Hibernation in Space
This segment of the workshop will explore the application of hibernation for short-term as well as long-term space missions.
- Technological gap for the existing hibernation theory and approaches for human spaceflights

Chapter 5: Professional Visits

2016 New Space conference

During the week of June 20th, 2016, I got the opportunity to attend the NewSpace Conference in Seattle, Washington. This conference brings together five important pillars of the space industry, including startups, long-term established companies, government agencies, private investors, and technology inventors (NewSpace,2016). The conference allowed me to connect with various professionals from the emerging NewSpace companies, and to further gain knowledge of the emerging commercial sector. I attended the conference from June 21st – June 23rd, during this time period I got the opportunity to meet professionals from Aerojet Rocketdyne, Planet (formerly known as Planet Labs), Deep Space Industries, Blue Origin, Nanoracks, Spaceflight Industries, Ball Aerospace, Space Frontier Foundation, and Space News. The primary purpose of the conference was to focus on the present and near-term challenges encountered in the commercial space industry, which allowed different companies and organization to explore potential collaborations and partnerships. Various panel discussions at the conference allowed me to gain an overall understanding of how the different components of the industry interact with each other and gain insight into their interpersonal relationships (e.g. government agencies and start-ups). The following are the list of tours organized specifically for all the ISU interns at NASA Ames.

Made in Space Tour

Made in Space headquarters are located in NASA Research Park (NRP), Business Development Engineer, Brad Kohlenberg walked us through the different areas of the office. The tour of the facility included visiting the prototype of the 3D printer, control room, and the prototype of the Additive Manufacturing Facility (AMF). Following the tour of the facility, we had a roundtable discussion of the future of the company and the potential technology advancements in the near term, such as fiber optics produced in Space.



Figure 8: ISU Interns at Made In Space

Planet

Planet (formerly known as Planet Labs) based in San Francisco, California, is a commercial space company, primarily focusing on collecting Earth imaging data using CubeSat Technology. The tour of Planet was three-fold, first, we were given a technological overview of their imaging satellites, followed by an overview of their product, customer market, and the tour was concluded by networking with few of the ISU alumni currently working employed at Planet. This interaction allowed us to learn about their career trajectories and further asked questions.



Figure 9

Figure:

Spire Global

Spire Global, also located in San Francisco, California, which also specialized in gathering data using a constellation of CubeSats. The primary market of the company is to collect data from monitoring maritime and weather data. The tour started with a roundtable discussion with the company's CEO, Peter Platzer, followed an overview of the working and future of the company by Russ Muzzolini, Spire's CTO.



Figure 10: ISU interns at Spire headquarters

Space Coast Trip

The space cost trip was organized to allow all the ISU interns to closely witness operations of space companies and government agencies. The objective of these visit was to gain insight regarding the internal working of the companies, with the aim to allow us to experience beyond the constraints of academia and learn more about the practical work experienced in the industry.

Space X

Space Exploration Technologies Cooperation (SpaceX), led by Elon Musk, is focused on developing low-cost space transportation for interplanetary travel with the primary goal of creating a colony on the Martian Surface. We visited the headquarters located in Hawthorne, California, which showcases Falcon 9 rocket cores, satellite design and production, vertical integration of satellites, 3D printing facility, and other testing facilities.



Figure 11

JPL

Tour of NASA's Jet Propulsion Laboratory (JPL) included visiting the visitor's center featuring 'Journey to the Planets and Beyond' which provides an overview of JPL's accomplishments over the course of time. The tour also includes visiting the Curiosity full -scale model, deep space network control room, and spacecraft integrating facility.

Xprize

Xprize is a non-profit organization that facilitates global prizes facilitating the development of exponential technology to create maximum global impact. The tour of the Xprize facility was lead by Dr. Andre Barton, another ISU alum, he walked us through the nature and impact of various Xprizes and the guidelines used for managing prize's panels and rules.

Virgin Galactic (The Spaceship Company, (TSC))

The tour of TSC was lead by Enrico Palermo, Vice President of Operations for The Spaceship Company. We visited the main manufacturing facility which showcases the MotherShip and the spaceship. Further, we learned about the design of the MotherShip, design of re-entry system of SpaceShip 2, and the lessons learned from the 2014 crash of SpaceShip 2.

Chapter 6: Recommendations and Conclusions

Distributed Systems

One of the significant misconceptions notices amongst the general public regarding the use of distributed system is limited to computer networked. However, it is essential to make an important distinction. Computer networks is referred to a medium used for interconnection various individual entities while enabling exchange of information between those entities based on a pre-defined protocol, distributed systems on the other hand, is developed on top of a network and appear to the end user as one single entity and it hides the existence of multiple autonomous computers and subsystems (Distributed Generation: Definitions, Benefits, Technologies & Challenges, 2016). Therefore, in order to extend this types of system in different domains, and to create a platform that allows communication over different applications, it is important to understand the requirements of Distributed System Design Checklist.

Synchronization of distributed systems has been an extensively studied area, however, the challenges associated with the robustness and fault tolerance of distributed computer networks still pose some major challenges. Nature has demonstrated that biological processes have continuously evolved to operate under exceptionally diverse and fault-prone environment, therefore in order to develop robust and reliable distributed systems it is important to extrapolate the synchronization models of the biological process to inspire the synchronization algorithm in distributed computing (Daliot, 2006).

Future Work

In order to conduct the SDS workshop in the fall of this year, the next step includes contacts experts from different arenas and explore potential utilization of distributed architectures for different systems. The current status of distributed system workshop is still in the development stage, and in order to further define the motivator of the workshop, it is required to contact experts already working in this field, and taking their experience as a defining factor in determining the motivator of the workshop. Currently, I have already interacted with Dr. David Korsmeyer, Director of Engineering; Rupak Biswas, Director of Exploration Technologies; Huy Tran, Director of Aeronautics. These meetings will have allowed me to connect with specialized experts in the field of robotics, astronautics, aeronautics, and human explorations. Similar interactions with other experts outside of NASA would us to have a much msore global image of the workshop and then further refine the scope of the workshop.

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